SERCK
A·V·I·A·T·I·O·N

Design of Compact Heat Exchangers for Aero-Gas Turbines

Presented by:-

Stan Payne Engineering Manager

Steve Hughes Team Leader: Development

Alex Allen New Technology Engineer

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (FROM - TO)
30-05-2001	Workshop Presentations	30-05-2001 to 01-06-2001

4. TITLE AND SUBTITLE
Design of Compact Heat Exchangers for Aero-Gas Turbines
Unclassified

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Payne, Stan ;
Hughes, Steve ;
Allen, Alex ;

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME AND ADDRESS
Serck Aviation
xxxxx
xxxxx, xxxxxxx

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS
Office of Naval Research International Field Office
Office of Naval Research
Washington, DCxxxxx

10. SPONSOR/MONITOR'S ACRONYM(S)
11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES
See Also ADM001348, Thermal Materials Workshop 2001, held in Cambridge, UK on May 30-June 1, 2001. Additional papers can be downloaded from: http://www-mech.eng.cam.ac.uk/onr/

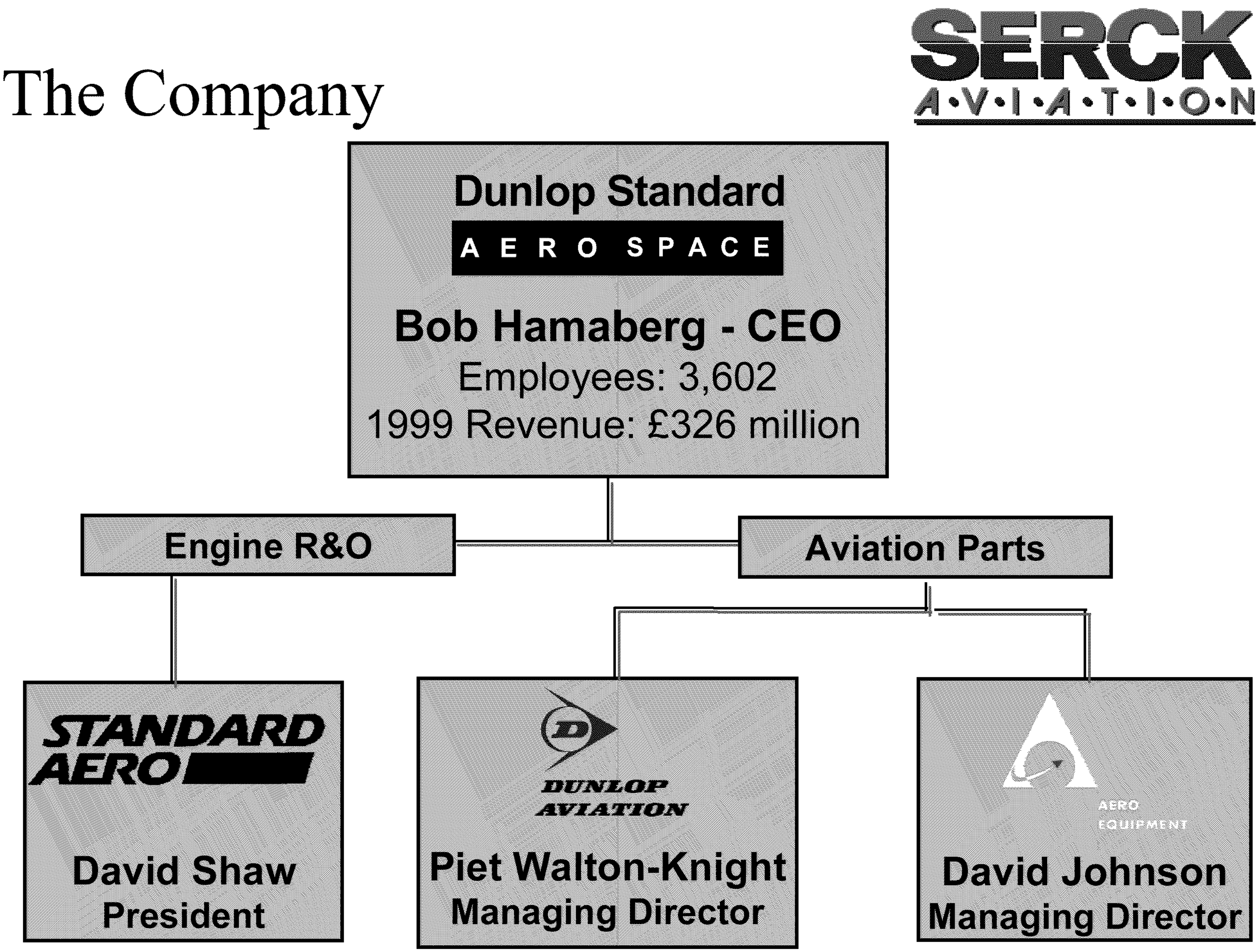
14. ABSTRACT
compact heat exchangers

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19. NAME OF RESPONSIBLE PERSON
			Public Release	16	Fenster, Lynn lfenster@dtic.mil
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER International Area Code Area Code Telephone Number 703767-9007 DSN 427-9007

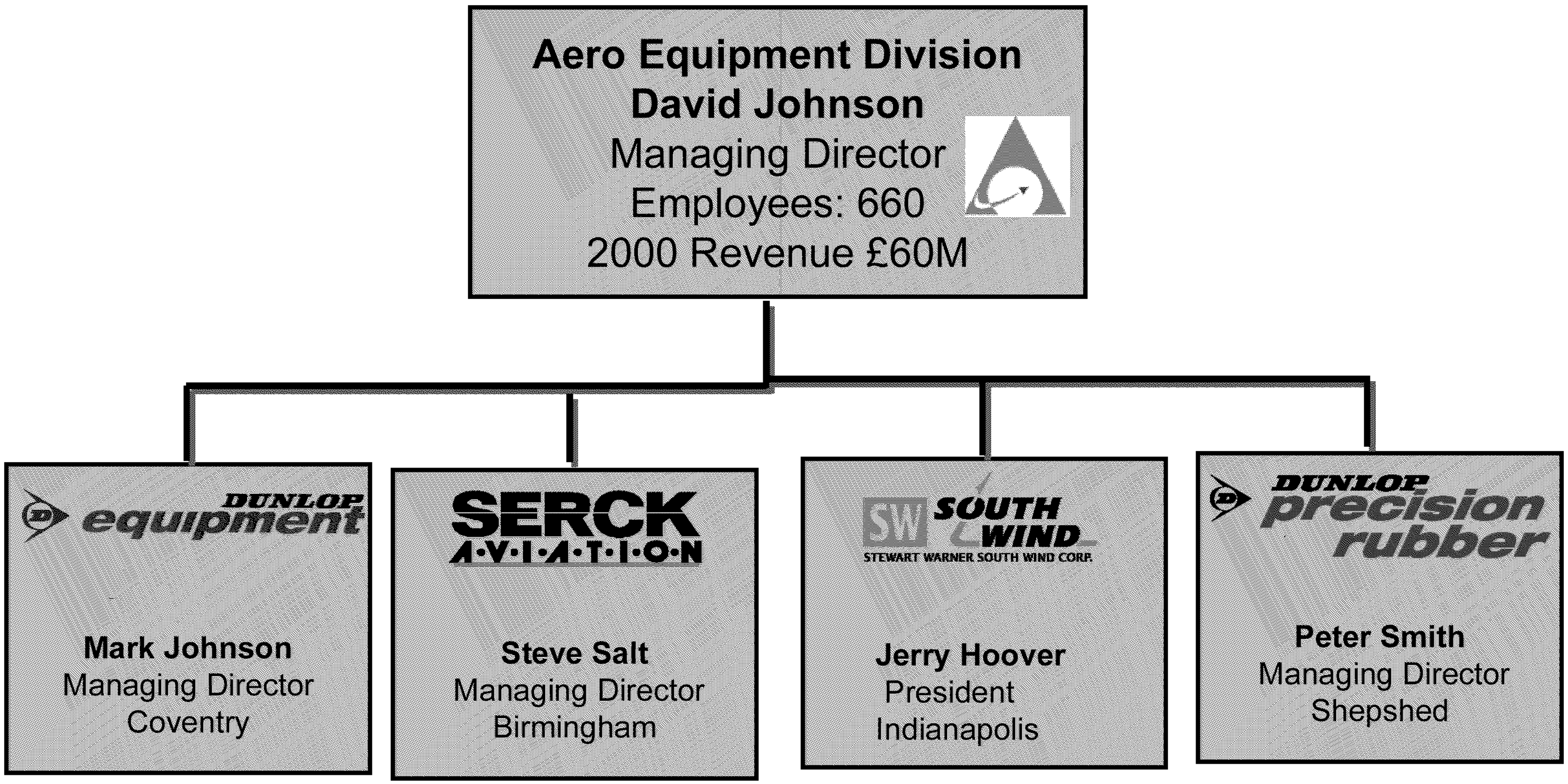
Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39.18

The Company


SERCK AVIATION
Dunlop Standard
AERO SPACE
Bob Hamaberg - CEO
Employees: 3,602
1999 Revenue: £326 million
Engine R&O
Aviation Parts
STANDARD AERO
David Shaw
President
DUNLOP AVIATION
Piet Walton-Knight
Managing Director
AERO EQUIPMENT
David Johnson
Managing Director

The Company

SERCK AVIATION



The Company

SERCK AVIATION

Headline Figures

- 2000 Sales £15m
- Employees 130
- Sole Market in Aerospace (91% export)
  - 85% Civil
  - 15% Military
- OEM - 59% of sales
- Spares - 27% of sales
- R&O - 14% of sales

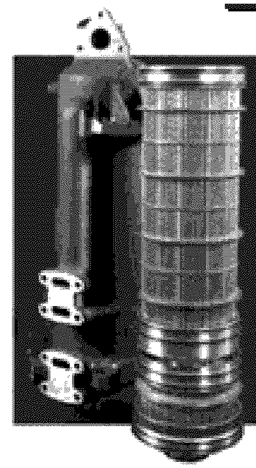
Product Applications include

- Pratt and Whitney
  JT8, JT9, PW2000, PW4000, PW6000, F100
- Rolls Royce
  Tay, Adour, RB211 524 & 535, Pegasus, Trent, RTM322
- General Electric
  F404, CF34
- SNECMA
  CFM56 All Marks
- Boeing 777
- BAe Harrier, Hawk

The Products

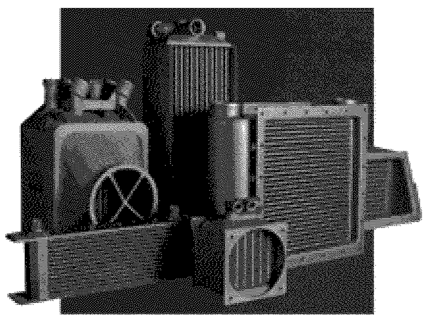
SERCK AVIATION

- Compact aluminium tubular construction offers the advantage of low weight
- Modular design for repair and overhaul provides low cost of ownership
- Well proven design and robust construction meets High Mean Time Between Failure requirements



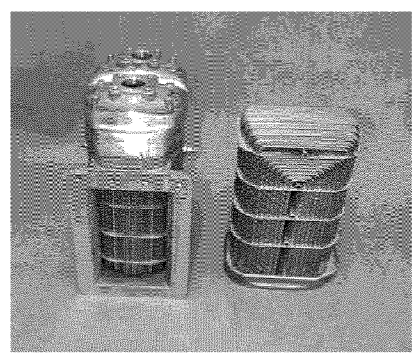
Shell & Tube

Plate & Fin



- Compact aluminium construction offers the advantage of low weight and cost.
- Brazing technology used provides high joint integrity

- Operating at approximately 1200°F to provide positive cooling to bearing chambers.
- Compact inconel tubular construction offers exceptionally long service life



High Temperature

SERCK AVIATION

Existing Products

Type	Applications			Heat transfer area/volume
	Fuel/Oil	Air/Oil	Air/Air	(Compactness)
• Tubular	✓	✓	✓	650 m^2/m^3
• Plate - Fin	✓*	✓	✓	800 - 1500 m^2/m^3

* Low Pressure & Temperature applications

Metal Foam Heat Exchanger

Construction

- Use of Metal foam, (nickel or aluminium) to increase heat transfer.
- Several designs under consideration.
- Rapid development of product expected.

Benefits

⇒ Cost Reduction

⇒ Weight Reduction

⇒ Performance Improvement

Metal Foam

Design Option - 1

- The heat exchanger built up of alternate plates.
- Note: the foam can be brazed to the plates.

Plate Fin/Foam Heat Exchanger

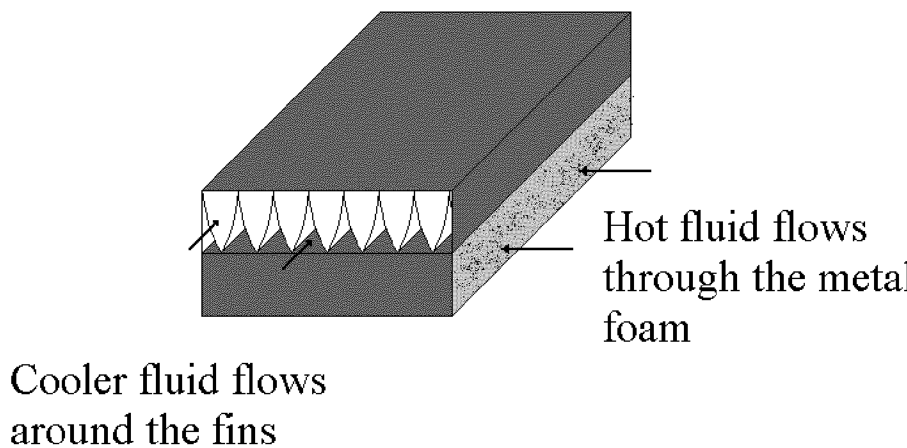


Fig.1

Metal Foam

Design Option - 2

⇨Contact between tubes and foam is fixed by brazing.

⇨Extended secondary surface for heat transfer.

⇨Increased turbulence of the shell-side fluid.

⇨The materials of construction have the same thermal expansion.

Tube - Foam Heat Exchanger

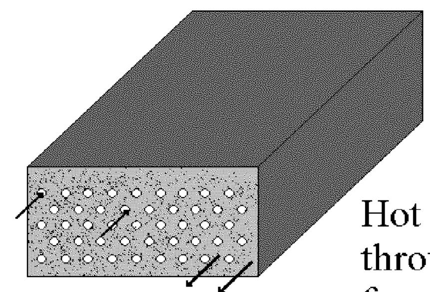


Fig.2

Metal Foam

SERCK AVIATION

Design Option - 3

Rotating Air/Oil Heat Exchanger & Separator:

Fig.3

⇨The Retimet® uses centrifugal action to force the denser oil to separate from the less dense air.

⇨Rotational energy required is available within the gearing system.

⇨Heat exchange possibilities present in such a configuration.

Metal Foam

SERCK AVIATION

Key points for consideration

Using metal foam:

- ⇨ Is the pressure drop acceptable ?
- ⇨ Fouling is likely to occur with a small-celled metal foam. Therefore, can we make larger cells without losing performance, or should it have a filter added?
- ⇨ Will Foam break/fragment under operation?

Metal Foam

Compactness of the Metal Foam HE

Estimated @ $\approx 2500\ m^2/m^3$

Compare with current tubular of $650\ m^2/m^3$

SERCK AVIATION

Design considerations

- Heat Transfer Performance & pressure loss
- Economic manufacturing cost
- Size, installation and removal for overhaul
- Dynamic loading induced from engine including vibration, blade out, manoeuvre
- Static loading from internal fluid pressures
- Thermal structural loading
- Material properties
- Fluid Properties
- Contamination / Fouling
- Repair and overhaul
- Life

SERCK AVIATION

Structural loading

⇨Design is evaluated by Finite Element Analysis (FEA) to determine resonant frequencies and displacement of the assembly and component parts over the engine frequency range (typically from 5 to 3000 Hz with 20G load applied above 100Hz).

⇨Static FEA for pressure loads

⇨Dynamic FEA for blade out (120G) and manoeuvre loads

SERCK AVIATION

⇨Thermal loading: particularly in the case of high temperature heat exchangers, a transient thermal FEA is completed using a validated model. This evaluates the induced metal temperatures and strain range throughout an entire flight cycle. A fatigue life analysis can be completed using the strain range, material properties and the number of defined engine cycles

⇨Computation Fluid Dynamics (CFD) is used to identify flow patterns (hot spots, reduced flow zones) within the unit which enables us to refine our heat transfer models. It also provides a good indicator of whether flow induced vibration will be a problem, and if so, how effective different design solutions will be.

SERCK AVIATION

Testing

Component Certification for flight worthiness testing will include:

- Vibration
- Pressure - including Proof/Burst/cycling
- May include PTF - pressure/temperature/flow cycling (although this may be avoided with the use of validated FEA)
- Impact
- Fire
- Icing
- Bird Strike/FOD.

Pass by analysis for sand, dust & fungus.